Announcements

- Homework for tomorrow…

  Ch. 33: CQs 4 & 5, Probs. 10, 12, & 50

  CQ1: CCW
  CQ2: push against resistive force
  33.2: 0.10 T, out of page
  33.3: 2.3 T, 1.0N

- Office hours…

  MW 10-11 am
  TR 9-10 am
  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm
  F 8-11 am, 2-5 pm
  Su 1-5 pm

Chapter 33

Electromagnetic Induction

(Lenz's Law & Faraday's Law)

Last time…

The *magnetic flux* of a *uniform* *B*-field passing through a loop is…

$$\boxed{\Phi_m = \vec{B} \cdot \vec{A} = BA\cos\theta}$$

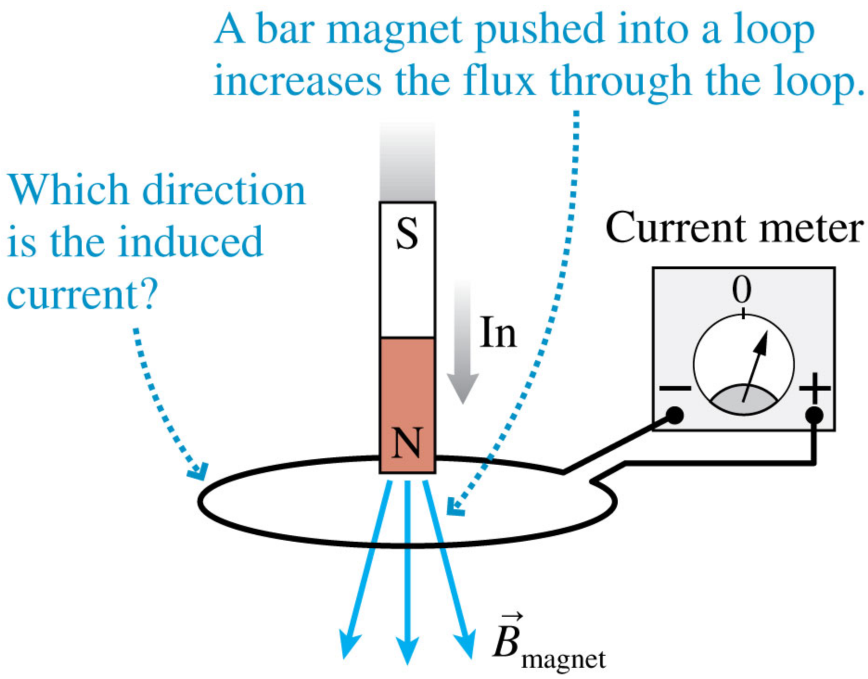
The *magnetic flux* of a *non-uniform* *B*-field passing through a loop is…

$$\boxed{\Phi_m = \int \vec{B} \cdot d\vec{A}}$$

33.4
Lenz's Law

Consider the figure below showing a bar magnet being pushed toward the loop, *increasing the flux through the loop*..

- Which direction is the *induced current* in the loop?



33.4
Lenz's Law

Lenz's Law

There IS an induced current in a closed, conducting loop *if and only if* the magnetic flux through the loop is *changing*.

The *direction* of the induced current is such that *the induced B-field opposes the change in flux*.

33.4
Lenz’s Law

Consider the figure below showing a bar magnet being pushed toward the loop, *increasing the flux through the loop*..

- Which direction is the *induced current* in the loop?

There is an induced current in a closed, conducting loop *if and only if* the magnetic flux through the loop is *changing*.

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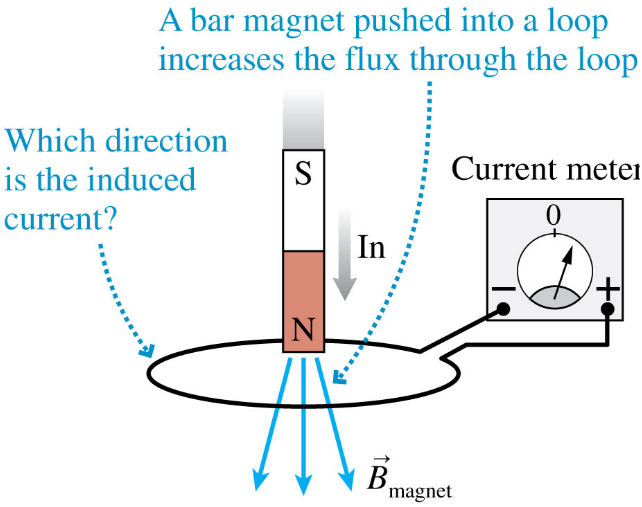


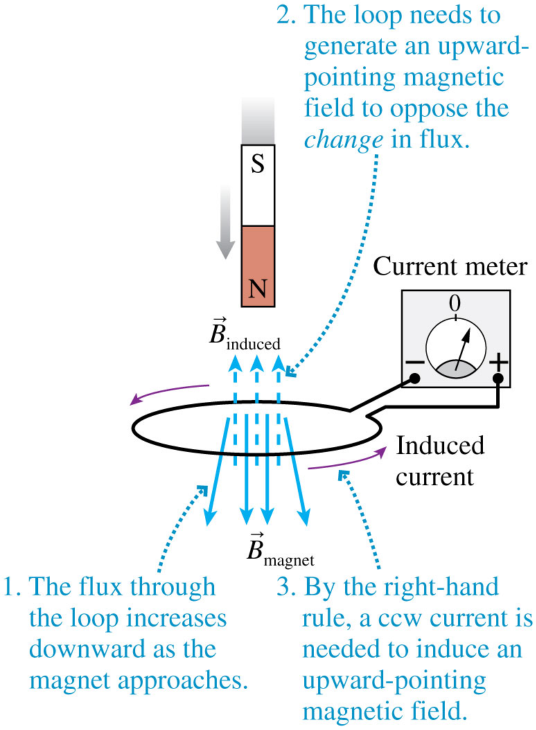
33.4
Lenz’s Law

Consider the figure below showing a bar magnet being pushed toward the loop, *increasing the flux through the loop*..

- Which direction is the *induced current* in the loop?

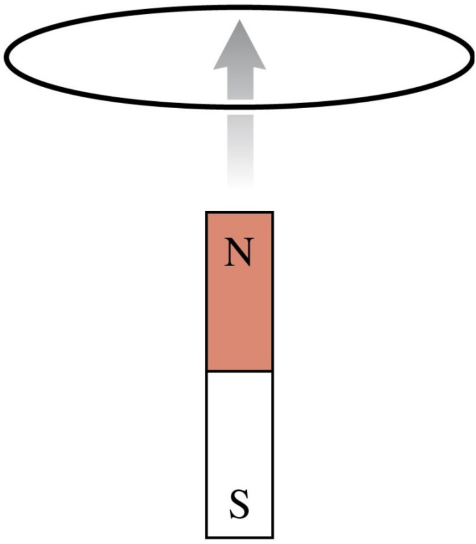
There is an induced current in a closed, conducting loop *if and only if* the magnetic flux through the loop is *changing*.

The *direction* of the induced current is such that *the induced B-field opposes the change in flux*.



Quiz Question 1

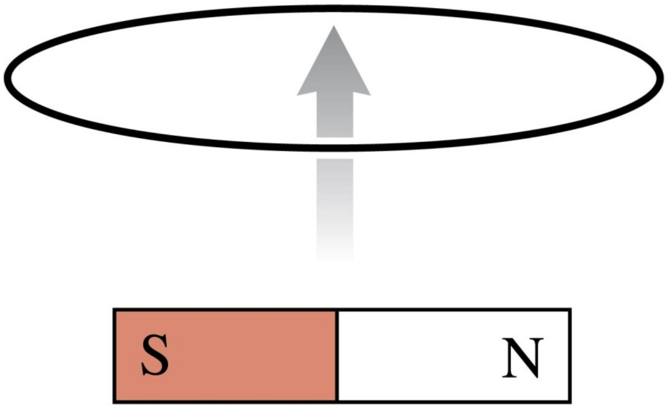
The bar magnet is pushed toward the center of a wire loop. Which is true?



1. There is a clockwise induced current in the loop.
2. There is a counterclockwise induced current in the loop.
3. There is no induced current in the loop.

Quiz Question 2

The bar magnet is pushed toward the center of a wire loop. Which is true?



1. There is a clockwise induced current in the loop.
2. There is a counterclockwise induced current in the loop.
3. There is no induced current in the loop.

Using Lenz's Law…

1. Determine the *direction* of the applied *B*-field.
   - The field must pass through the loop.

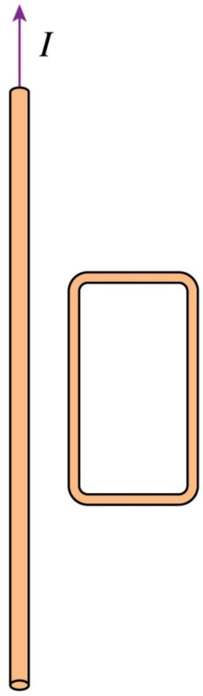
2. Determine how the flux (of the applied *B*-field) is *changing*.

3. Determine the direction of the *induced B*-field that will *oppose the change in the flux*.

4. Determine the *direction* of the *induced current*.

Quiz Question 3

The current in the straight wire is *decreasing*. Which is true?

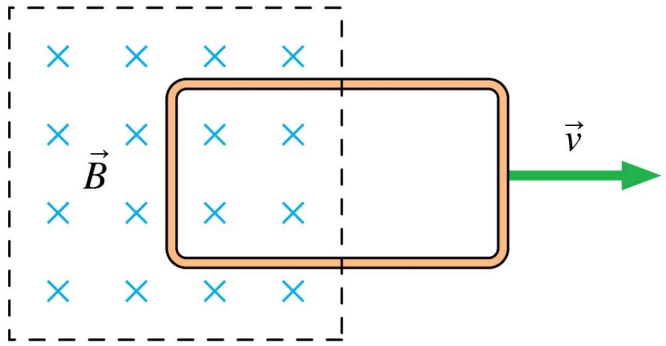


1. There is a clockwise induced current in the loop.
2. There is a counterclockwise induced current in the loop.
3. There is no induced current in the loop.

Quiz Question 4

The *B*-field is confined to the region inside the dashed lines; it is *zero* outside. The metal loop is being pulled out of the *B*-field. Which is true?

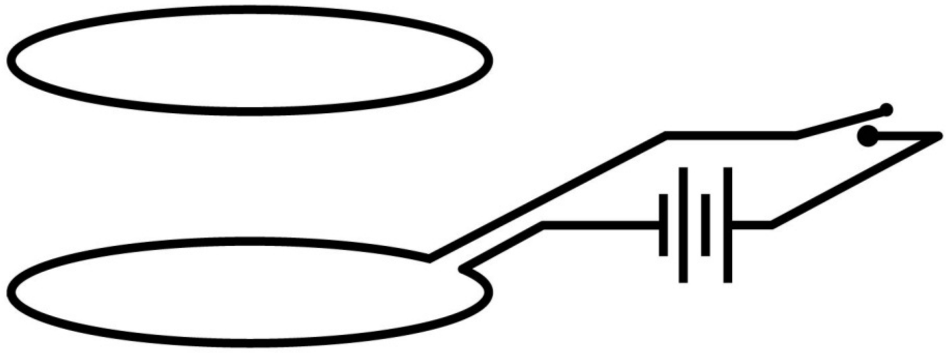
$v \times \vec{B}$



1. There is a clockwise induced current in the loop.
2. There is a counterclockwise induced current in the loop.
3. There is no induced current in the loop.

Quiz Question 5

Immediately after the switch is closed, the lower loop exerts _____ on the upper loop.



1. a torque
2. an upward force
3. a downward force
4. no force nor torque

33.5
Faraday's Law

- An emf is induced in a conducting loop if the magnetic flux through the loop *changes*.
- The magnitude of the emf is:

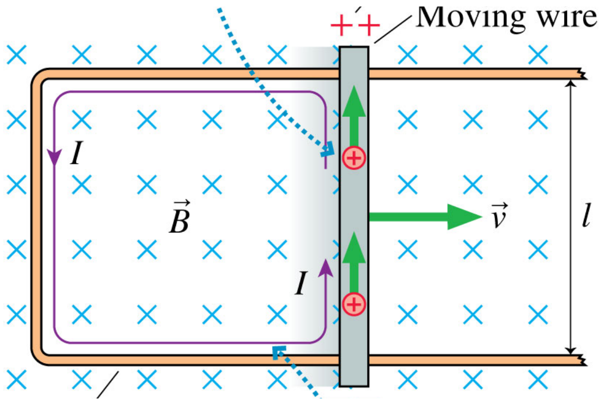
$$\boxed{\mathcal{E} = \left| \frac{d\Phi_m}{dt} \right|}$$

The direction of the emf is such as to drive an *induced current* in the direction given by Lenz's law.

Motional emf, revisited…

Motional emf for a conductor moving with velocity v *perpendicular* to the B-field…

$$\boxed{\mathcal{E} = vlB}$$



The *induced current* in the circuit….

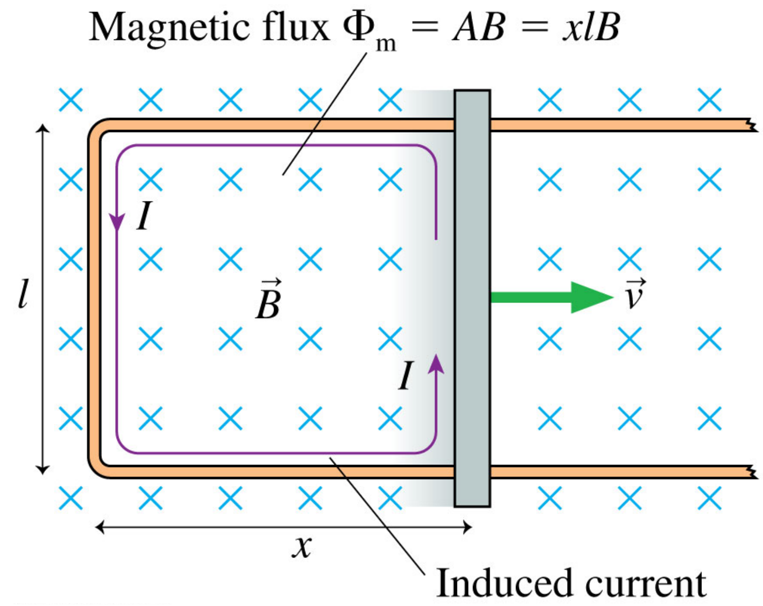
$$\boxed{I = \frac{vlB}{R}}$$

Using Faraday's Law…

An emf is induced in a conducting loop if the magnetic flux through the loop *changes*.

$$\mathcal{E} = \left| \frac{d\Phi_m}{dt} \right|$$

so,



The direction of the emf is such as to drive an *induced current* in the direction given by Lenz's law.

$$\Phi_m = \vec{B} \cdot \vec{A}$$
$$= BA = B\ell x$$

$$\mathcal{E} = \frac{d\Phi_m}{dt} = \frac{d}{dt}(B\ell x)$$
$$= B\ell \frac{dx}{dt}$$
$$= B\ell v$$

Using Faraday's Law…

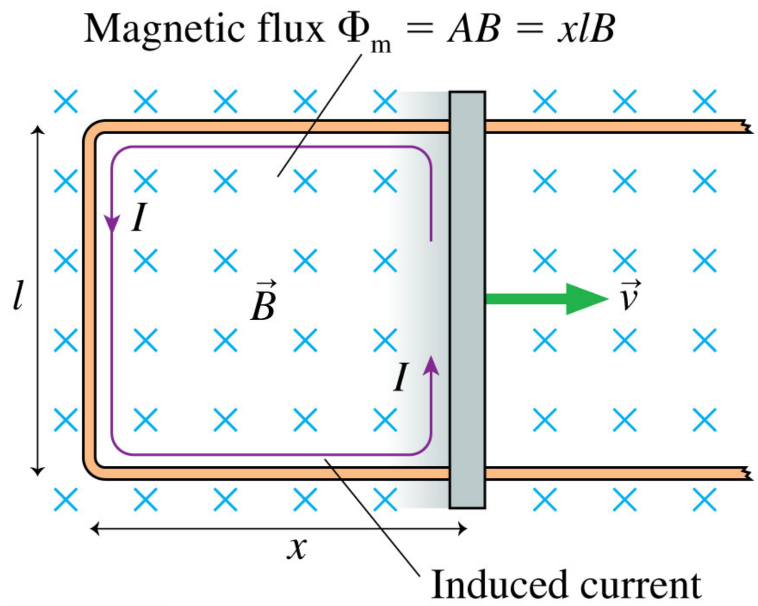
An emf is induced in a conducting loop if the magnetic flux through the loop *changes*.

$$\mathcal{E} = \left| \frac{d\Phi_m}{dt} \right|$$

so,

$$\boxed{\mathcal{E} = vlB}$$

$$\boxed{I = \frac{vlB}{R}}$$



The direction of the emf is such as to drive an *induced current* in the direction given by Lenz's law.